EARTH SATELLITE CORPORATION
(EarthSat)

1747 PENNSYLVANIA AVENUE, N.W., WASHINGTON, D. C. 20006
TELEPHONE: (202) 223-8100 TELEX: EARTHSAT64449

July 6, 1973

National Aeronautics and
Space Administration
Goddard Space Flight Center
Greenbelt, Maryland 20771

ATTENTION: Distribution

RE: Bi-Monthly Progress Report SR #141
ERTS-1, Snow Enhancement: NAS5-21744

Gentlemen:

Earth Satellite Corporation (EarthSat) is pleased to submit a progress report for the period of May 1, 1973 to June 30, 1973. To facilitate NASA's review, a consistent format has been adopted for all progress reports prepared by Geosciences and Environmental Applications Division. A Task Status Report can be referenced in Appendix A.

A. TITLE: Facilitating the Exploitation of ERTS-Imagery Using Snow Enhancement Techniques (SR #141) - NAS5-21744

B. PRINCIPAL INVESTIGATOR: Dr. Frank J. Wobber (P-511)

C. CONTRIBUTORS: Dr. Frank J. Wobber
Mr. Kenneth Martin
Mr. Roger Amato

D. SUMMARY OF ACCOMPLISHMENTS: Manual, enhanced manual and automated analysis of ERTS-1 data of snow-free and snow-covered terrain has continued through this reporting period. An evaluation of the detectability of geological and environmental features utilizing multispectral imagery of snow-covered terrain has been completed. A detailed multi-sensor analysis of the second test site within the New England Test Area has been initiated. A capsulized summary of principal accomplishments follows:

- A meeting was held with the Scientific Monitor, Dr. Paul Lowman to describe the continuing progress of the experiment, and modifications in the emphasis given test areas.

- An updated revision of the Final Report Outline has been prepared to expand the detail contained within the previous version. This has been submitted to the monitors for their review.

- A list of snow depth descriptors has been prepared to standardize references to both the depth and extent of snow cover (Table 1). These categories simplify references to snow depth within which the enhancement capabilities of snow cover are generally the same.

- An evaluation of the enhancement capabilities of several viewing techniques has been conducted. Use of the Film Sandwich and Ronchi grating produced a slight increase in lineament detail.

- An assessment of the detectability of a wide-range of geological and environmental features utilizing MSS imagery and color composites of snow-covered terrain has been completed. Detectability ratings are contained in Table 2.

- A comparative fracture analysis test of snow-free and snow-covered imagery of the same area within the New England Test Area has been conducted. An assessment of the first three frames to be analyzed indicates that a greater number of fractures were mapped on the snow-covered imagery. In all three frames, the total length of fractures mapped was greatest on the snow-covered imagery.

- Sections of the Final Report have been prepared as the experiment progresses.

- Analysis of the results of automated enhancement of a snow-free CCT is continuing. As of this time no significant results have been attained from preferential enhancement in selected directions.

- A second test site for detailed multi-sensor analysis has been selected within the New England Test Area, and an in-depth analysis is in progress. The test site is located in the area of Torrington, Connecticut.

E. SIGNIFICANT RESULTS: Detection and analysis of fracture systems can be more effectively conducted utilizing snow cover as an enhancement tool. From analysis within the Great Barrington Test Site it appears that the use of aeromagnetic data effectively supplements lineament data acquired using ERTS imagery. Coincidence of lineaments derived from aeromagnetics with lineaments interpreted from ERTS imagery apparently indicate the presence of mineralized fracture systems and dikes. Utilizing both tools can increase the speed and efficiency of mineral exploration and geological mapping in areas where the bedrock is obscured by a thick unconsolidated sediment cover.

F. PROBLEMS

- The lack of snow-cover within the Maryland-Virginia Test Area; (a) did not afford the investigators the opportunity to study transient melt phenomena, and (b) eliminated the opportunity to test snow enhancement by acquiring fracture data within an area of deep residual soils. It is in such areas where the benefits of the technique may be maximized.

- Due to the lack of snowfall within the Maryland-Virginia Test Area, snow enhancement techniques could not be developed for fracture mapping in this area. To compensate for this and to supply NASA with an increased quality and volume of information and early results, the investigators (in consultation with monitors) increased the depth of analysis for the New England Test Area. This has created an imbalance in travel funds necessary to conduct field validation of interpreted lineaments due to the greater intensity of analysis (i.e. increased field time), and the greater distance of the New England Test Area

G. RECOMMENDATIONS FOR TECHNICAL CHANGES: None

H. CHANGES TO STANDING ORDER FORMS: None

I. OVERVIEW OF INVESTIGATION: The last snow-covered imagery for the New England Test Area (1258-15073 and 1258-15000) acquired on April 7th has been received. Fracture analysis is being conducted using this imagery.

Viewing techniques (e.g. Ronchi grating and film sandwich) to enhance lineament detection have been evaluated. Under optimum exposure conditions (e.g. proper density of film sandwich transparencies) both techniques supply a limited amount of additional lineament data. A complete evaluation of these techniques will be presented within the Final Report.

Snow-free versus snow-cover fracture analysis testing was conducted in the New England Test Area utilizing two senior photogeologists unfamiliar with this test area. An early assessment of the results suggests that in the majority of frames analyzed, a greater number of fractures were mapped on the snow-covered ERTS image. In all cases, the total length of fractures mapped was greatest on the snow-covered image.

Progress has been made in rapidly developing a new analysis technique for ERTS imagery. Additional support to refine the technique in areas of deep residual soil (where fracture data is especially difficult to acquire) and demonstrate a practical application of the technique must yet be accomplished.

Questions concerning this report should be directed to the undersigned at (202) 223-8100.

Sincerely yours,

Frank J. Wobber
Director
Geosciences and Environmental
Applications Division

FJW/rlt

TABLE 1: SNOW COVER DESCRIPTORS[1/]

SNOW DEPTH CATEGORIES[2/]			
	SNOWFALL (Accumulation)	SNOW MELT (Dissipation)	THICKNESS (Inches)
I	Dusting	Film	<1
II	Lt. Cover	Slush	1-2
III	Medium Cover		3-6
IV	Thick Cover		6-9
V	Heavy Blanket		>9

SNOW COVER DISTRIBUTION		
Sporadic	Discontinuous	Continuous
snow-free ground predominates	snow-covered ground predominates	even snow cover

[1/] Utilized as standardized, general descriptors of snow cover determined from ERTS image analysis or direct ground observation.

[2/] Snow depth categories are collective groups of individual snow depths designed to simplify references to snow depth and within which the enhancement capabilities of snow cover are generally the same. (See September 1, 1972 - April 30, 1973 Semi-annual progress report for tabular evaluation of enhancement capabilities).

TABLE 2: DETECTABILITY OF GEOLOGICAL AND ENVIRONMENTAL INFORMATION UTILIZING ERTS-1 MULTISPECTRAL IMAGERY OF SNOW-COVERED TERRAIN

GEOLOGICAL/ENVIRONMENTAL FEATURES	MSS BANDS				
	BAND 4	BAND 5	BAND 6	BAND 7	COLOR COMPOSITE
FRACTURE-LINEAMENTS (Fractures)	5	1	3	2	3
STRATIGRAPHIC LINEAMENTS	3	2	4	5	1
CULTURAL LINEAMENTS (Transmission Lines, Airport Runways)	3	1	4	5	2
SNOW DEPTH ESTIMATION	1 1/	4	5	1 1/	3
VEGETATION	3	2	4	5	1
ICE DISCRIMINATION 2/	1 3/	4	5	1 3/	3
OUTFALLS 4/ (a) Ice Cover	1	2	4	5	3
(b) Snow and Ice Cover	2	1	4	5	3
LAND USE	3	2	4	5	1

NOTE: The number one (1) signifies the best rating.

1/ Band 4 images a very light snow cover which under some conditions is not imaged on Band 7. The two bands utilized can supply complementary depth information, particularly for discrimination of very light snow cover.

2/ Ice cover as discriminated from snow and ice cover on lakes, ponds and reservoirs.

3/ Radiation sensitive to band 4 (500-600nm.) wavelengths are highly reflected by ice cover while infrared radiation sensitive to Band 7 (800-1100nm.) tends to be absorbed.

4/ Outfalls which are thermally manifested as unfrozen areas within predominantly frozen water bodies.

Dr. Frank J. Wobber SR #141 NAS5-21744

SIGNIFICANT RESULTS

May 1, 1973-June 30, 1973

Detection and analysis of fracture systems can be more effectively conducted by utilizing snow-cover as an enhancement tool. From analysis within the Great Barrington Test Site it appears that the use of aeromagnetic data effectively supplements lineament data acquired using ERTS imagery. Coincidence of lineaments derived from aeromagnetics with lineaments interpreted from ERTS imagery apparently indicate the presence of mineralized fracture systems and dikes both tools can increase the speed and efficiency of mineral exploration and geological mapping in areas where the bedrock is obscured by a thick unconsolidated sediment cover.

APPENDIX A

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TASK STATUS REPORT

	TASK	STATUS	COMMENTS
	PHASE I		
1.0	Establish Technical Interface with NDPF	Completed 6/30/72	Meetings held with the scientific monitor: ERTS-simulation U-2 aircraft imagery analyzed.
2.0	Assemble Geological Maps and Snow Cover Data	Completed 10/31/72	Subscription to New England Climatological Data: State geological maps of Massachusetts, Connecticut, Vermont, New Hampshire, and geological quadrangle maps for western Massachusetts purchased and analyzed.
3.0	Select and Establish Snow Points	Completed 2/28/73	A comprehensive net of weather stations has been organized. Physical ground points for light aircraft survey have been minimized.
4.0	Base Map & Underflight Preparation	Completed 10/31/72	Base map scale determined: Other New England investigators contacted.
5.0	Lineament Map Pre-Preparation	Completed 8/30/72	Radar imagery of Massachusetts, Connecticut, and Rhode Island was intensively analyzed to prepare geological lineament maps of the test area.
6.0	Snow Cover and Snow Melt Survey	Completed 12/31/72	Survey package designed and sent to newspapers in low density snow depth reporting areas. Readers indicating interest have been supplied with snow-depth reporting materials.
	PHASE II		
7.0	Select & Analyze Snow Free ERTS Imagery	Completed 2/28/73	All ERTS-1 imagery of the test area analyzed upon receipt. Images 1096-15072-5 & 7 and 1096-15065-5 & 7 of the New England Test area and 1062-15190-5 & 7 of the Maryland Test area are being enlarged to a 1:250,000 scale to serve as a photo base map.

 Completed Tasks

TASK	HEADING	STATUS	COMMENTS
2.0	Analyze Snow-Covered Imagery	Pending completion of ADP	All ERTS-1 imagery of the test area analyzed upon receipt. Intensive analysis of frames 1132-15074 & 1168-15065 has been conducted and is being compared with snow-free data. U-2 snow-covered imagery of the test area has also been analyzed.
3.0	Prepare & Submit A Preliminary Data Analysis Plan	Completed 12/31/72	A Data Analysis Plan has been submitted and approved by the ERTS Contracting Officer.
		PHASE III	
1.0	Modify Manual Optical & ADP Enhancement Techniques.	Completed 2/28/73	A re-evaluation of techniques and approach has been conducted. No major changes were necessary - minor modifications have been integrated.
2.0	Process ERTS Imagery Though Last Snow-Covered Period.	Underway	
3.0	Prepare Final Report	Underway	Sections of Final Report are being written as the experiment progresses. Sections I, II and III (Introduction, Background and Design) complete in draft form. Subsections in Section IV (Analytical Procedures) and V (Results) are complete.
4.0	Prepare NDPF User Manual	Pending Completion of Final Report	

 - Completed Tasks

APPENDIX B

Dr. Frank J. Wobber SR #141 NAS5-21744

July 6, 1973

PROGRESS REPORT SUMMARY

Reporting Period: May 1, 1973 - June 30, 1973

CATEGORY: 8-Interpretation Techniques Development

SUB-CATEGORY: C-General

TITLE: Facilitating the Exploitation of ERTS-Imagery Using Snow Enhancement Techniques - SR #141: NAS5-21744

PRINCIPAL INVESTIGATOR: Dr. Frank J. Wobber (P-511)

CO-INVESTIGATOR: Mr. Kenneth R. Martin

SUMMARY:

The last snow-covered imagery for the New England Test Area (1258-15073 and 1258-15000) acquired on April 7th has been received. Fracture analysis is being conducted with this imagery. Techniques (e.g. use of Ronchi grating and film sandwich) to enhance lineament detection have been evaluated. Tests indicated that under optimum exposure conditions (e.g. proper density of film sandwich transparencies) both techniques can supply a limited amount of additonal lineament data. Comparative snow-free vs. snow-cover fracture analysis tests were conducted in the New England Test Area. An early assessment of the results indicates that in the majority of frames analyzed, a greater number of fractures were mapped on the snow-covered ERTS image. In all cases, the total length of fractures mapped was greatest on the snow-covered image.

Significant Results

Detection and analysis of fracture systems can be more effectively conducted by utilizing snow-cover as an enhancement tool. From analysis within the Great Barrington Test Site it appears that the use of aeromagnetic data effectively supplements lineament data acquired using ERTS imagery. Coincidence of lineaments derived from aeromagnetics with lineaments interpreted from ERTS imagery apparently indicate the presence of mineralized fracture systems and dikes both tools can increase the speed and efficeincy of mineral exploration and geological mapping in areas where the bedrock is obscured by a thick unconsolidated sediment cover.

APPENDIX C

ERTS IMAGE DESCRIPTOR FORM

(See Instructions on Back)

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ID

DATE 2 July 1973

PRINCIPAL INVESTIGATOR Frank J. Wobber

GSFC

ORGANIZATION EarthSat

PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS
	LAKE	RIVER	SNOW	
1258-15073-4	X	X	X	Mountains
1258-15073-5	X	X	X	Valley
1258-15073-6	X	X	X	Massif
1258-15073-7	X	X	X	Lineament
				Bedding
				Thrust Fault
				Dendritic Drainage
1258-15080-4	X	X	X	Mountains
1258-15080-5	X	X	X	Valley
1258-15080-6	X	X	X	Basin
1258-15080-7	X	X	X	Dike
				Lineament
				Bedding
				Dendritic Drainage
				Thrust Fault
				Normal Fault
				Coastal Plain
				Coastline
				Urban Area
1257-15021-4	X	X	X	Coastline
1257-15021-5	X	X	X	Urban Area
1257-15021-6	X	X	X	Island
1257-15021-7	X	X	X	
1293-15020-4	X	X	X	Basin
1293-15020-5	X	X	X	Dike
1293-15020-6	X	X	X	Bedding
1293-15020-7	X	X	X	Dendritic Drainage
				Coastline
				Island

*FOR DESCRIPTORS WHICH WILL OCCUR FREQUENTLY, WRITE THE DESCRIPTOR TERMS IN THESE COLUMN HEADING SPACES NOW AND USE A CHECK (✓) MARK IN THE APPROPRIATE PRODUCT ID LINES. (FOR OTHER DESCRIPTORS, WRITE THE TERM UNDER THE DESCRIPTORS COLUMN).

MAIL TO ERTS USER SERVICES
CODE 563
BLDG 22 ROOM E413
NASA GSFC
GREENBELT, MD. 20771
301-982-5406

GSFC 37-2 (7/72)